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the AEROVOX Research Worker

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring to the Radio Experimenter and Engineer authoritative, first hand information on condensers and resistances for radio work.

VOL. 12, NO. 3 MARCH, 1940 A. R. SATULLO 50c per year in U.S.A. 60c per year in Canada

# Aids in Filter Designing

*By the Engineering Department, Aerovox Corporation*

FILTER networks may be built up from reactances in different configurations but this article is confined to the well-known "ladder"-networks of the type shown in Figure 1. The series impedance $Z_1$ and the shunt impedance $Z_2$ may consist of inductive reactances or capacitive reactances or several in combination. They may or may not have appreciable resistance.

Such a ladder network can be considered as built up of several sections either of the "T"-type or the "Pi"-type as illustrated in Figure 2. Note that each of the two series arms of the T-section are equal to $Z_1/2$, since adding several sections together will put two of these in series, resulting in a full-series impedance $Z_1$. For a similar reason, the individual Pi-section has shunt arms equal to $2Z_2$, for, when two sections are added together two of these are in parallel and form the full-shunt impedance $Z_2$.

When a filter ends with half a series-arm it is said to be mid-series terminated. When it ends with the double shunt-arm it is mid-shunt terminated.

The image impedances of a filter are the two impedances, not necessarily alike, which will simultaneously terminate the filter at its two ends so there will be no reflection loss. This occurs when the image impedance is equal to the impedance looking into the filter at that end.

When the two image impedances are equal, the filter is symmetrical, and they are equal to $Z_0$, the characteristic impedance.

The characteristic impedance and/or the image impedance may be found by measuring the impedance of the filter at one end with the other end left open and again with the other end shorted. The desired impedance equals the geometric mean of the two values obtained.

The image impedance and characteristic impedance generally vary with frequency so the two measurements must be carried out at the same frequency.

## CONSTANT-K FILTER

The filters discussed here are of the "constant-k type" which means that the product $Z_1Z_2$ is constant for all frequencies and equal to $k^2$. This value k is again equal to the characteristic impedance of the filter over the greater part of the pass band and equal to the value R used in the calculations.

Such a filter, when properly terminated in its image impedance, acts as a resistance load on the generator throughout the pass-band, but, at the cut-off frequency the load becomes either zero or infinite and thereafter it is imaginary. In other words, in the attenuation band the filter acts as a reactive load, does not take any energy from the generator, and does not transmit any energy to its terminating impedance.

Figure 3 shows the hook-up of four types of filters with the equations for their elements while Tables I and II contain tabulations of these values for different cut-off frequencies.

In general it will be necessary to use filters of more than one section if a sharp enough cut-off is to be obtained and these sections need not necessarily be the same. Other sections, having special attenuation characteristics can be "derived" from the filter sections of the "prototype" described here. These will be dealt with in a later article.

## USE OF THE TABLES

Table I lists the element values for low-pass and high-pass filters with 500 ohms and 10,000 ohms characteristic impedance. These are the values for the full series arm and the full shunt arm, $Z_1$ and $Z_2$ as in Figure 1. They are given in henries and microfarads except in some cases where microhenries and micro-microfarads are used.

The cut-off frequencies listed were selected to minimize the work to be done by the user. All element values are inversely proportional to the cut-off frequency. This information will serve to find data for filters having a cut-off frequency which may not be

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listed. For instance: A low-pass filter working out of and into a 500 ohm line and having a cut-off frequency of 150 cycles requires a coil of 1.06 henry inductance and a shunt condenser of 4.24 microfarads. For a cut-off frequency of 1500 cycles these values become .106 henry and .424 mfd. When the cut-off frequency is 15 mc. the values become 10.6 microhenry and 42.4 mmfd. Note that the figures remain the same but the decimal point only has been moved. A guide to the placing of the decimal point is found by noting that the required values must be between those for 10 and 30 mc.

When a filter is to be designed for a different characteristic impedance R, find the required data first for a 500 ohm filter. Then multiply the inductance value by R/500 and divide the capacity value by the same factor.

In Table II is listed the required data for a band-pass filter of 500 ohms, having different band-widths and different mid-frequencies, $f_m$. Usually the two cut-off frequencies for the filter are given. Let us call these $f_1$ and $f_2$, $f_1$ being the smaller one. The mid-frequency is then the geometric mean between the two or $f_m^2 = f_1 f_2$. The band-width, for the purpose of this table is defined as $(f_2 - f_1)/f_m$. So, for instance, a filter with a lower cut-off frequency of 625 cycles and an upper cut-off frequency of 1625 cycles has a mid-frequency of 1000 cycles and a band-width of unity. A filter with the same mid-frequency and a band-width of .2 would have cut-off frequencies of 910 and 1110 cycles.

All values are given in henries and microfarads except those marked "m" which are in microhenries and micromicrofarads.

Similar to Table I, element values for different mid-frequencies and different characteristic impedances can be obtained by interpolation or displacement of the decimal point, remembering that all element values are inversely proportional to the mid-frequency, the inductances are proportional and the capacities inversely proportional to the characteristic impedance.

When a different band-width is desired, the element values are found from the following rule: $L_2$ and $C_1$ are proportional and $L_1$ and $C_2$ inversely proportional to the band-width. Element values for a band-width of unity are the same as those given in Table I.

To find the values of capacity and inductance of a band-suppression filter with a characteristic impedance of 500 ohms proceed as follows:—$L_2$ of the shunt arm is equal to $\frac{1}{4}L_1$ of the band-pass filter, and $L_1$ of the series arm is equal to $4L_2$ of the band-pass filter. $C_2$ of the shunt arm, in series with $L_2$, is equal to $4C_1$ of the band-pass filter; and $C_1$ of the series arm in parallel with $L_1$ is equal to $\frac{1}{4}C_2$ of band-pass filter.

## TABLE I LOW-PASS and HIGH-PASS FILTER DATA

| R = 500 ohms | | | | | R = 10,000 ohms | | | |
|---|---|---|---|---|---|---|---|---|
| | Low-pass | | High-pass | | Low-pass | | High-pass | |
| $f_c$ (cycles) | $L_1$ (henries) | $C_2$ (mfds.) | $L_2$ (henries) | $C_1$ (mfds.) | $L_1$ (henries) | $C_2$ (mfds.) | $L_2$ (henries) | $C_1$ (mfds.) |
| 30 | 5.31 | 21.2 | 1.33 | 5.31 | 106. | 1.06 | 26.5 | .265 |
| 100 | 1.59 | 6.37 | .398 | 1.59 | 31.8 | .318 | 7.96 | .0796 |
| 150 | 1.06 | 4.24 | .265 | 1.06 | 21.2 | .212 | 5.31 | .0531 |
| 200 | .796 | 3.18 | .198 | .796 | 15.9 | .159 | 3.98 | .0398 |
| 250 | .637 | 2.55 | .159 | .637 | 12.7 | .127 | 3.18 | .0318 |
| 300 | .531 | 2.12 | .133 | .531 | 10.6 | .106 | 2.65 | .0265 |
| 350 | .455 | 1.82 | .114 | .455 | 9.09 | .0909 | 2.28 | .0228 |
| 400 | .398 | 1.59 | .0995 | .398 | 7.96 | .0796 | 1.99 | .0199 |
| 450 | .354 | 1.41 | .0884 | .354 | 7.07 | .0707 | 1.77 | .0177 |
| 500 | .318 | 1.27 | .0796 | .318 | 6.37 | .0637 | 1.59 | .0159 |
| 550 | .289 | 1.16 | .0723 | .289 | 5.78 | .0578 | 1.45 | .0145 |
| 600 | .265 | 1.06 | .0663 | .265 | 5.31 | .0531 | 1.33 | .0133 |
| 650 | .245 | .979 | .0612 | .245 | 4.90 | .0490 | 1.22 | .0122 |
| 700 | .227 | .909 | .0568 | .227 | 4.54 | .0454 | 1.14 | .0114 |
| 750 | .212 | .849 | .0531 | .212 | 4.24 | .0424 | 1.06 | .0106 |
| 800 | .199 | .796 | .0497 | .199 | 3.98 | .0398 | .995 | .00995 |
| 850 | .187 | .749 | .0468 | .187 | 3.74 | .0374 | .936 | .00936 |
| 900 | .177 | .707 | .0442 | .177 | 3.54 | .0354 | .884 | .00884 |
| 950 | .168 | .670 | .0419 | .168 | 3.36 | .0336 | .839 | .00839 |
| 1* | .159 | .637 | .0398 | .159 | 3.18 | .0318 | .796 | .00796 |
| 3* | .0531 | .212 | .0133 | .0531 | 1.06 | .0106 | .265 | .00265 |
| 10* | .0159 | .0637 | .00398 | .0159 | .318 | .00318 | .0796 | 796# |
| 30* | .00531 | .0212 | .00133 | .00531 | .106 | .00106 | .0265 | 265# |
| 100* | .00159 | .00637 | 398† | .00159 | .0318 | 318# | .00796 | 79.6# |
| 300* | 581† | .00212 | 133† | 531# | .0106 | 106# | .00265 | 26.5# |
| 1** | 159† | 637# | 39.8† | 159# | .00318 | 31.8# | 796† | 7.96# |
| 3** | 53.1† | 212# | 13.3† | 53.1# | .00106 | 10.6# | 265† | 2.65# |
| 10** | 15.9† | 63.7# | 3.98† | 15.9# | 318† | 3.18# | 79.6† | 0.796# |
| 30** | 5.31† | 21.2# | 1.33† | 5.31# | 106† | 1.06# | 26.5† | 0.265# |

NOTE: *Kilocycles, **Megacycles, †Microhenries, #Micromicrofarads

## TABLE II BAND-PASS FILTERS (R = 500 OHMS)

| Band Width | $f_m$ = | 100 cycles | 1000 cycles | 1500 cycles | 2000 cycles | 2500 cycles | 3000 cycles | 3500 cycles | 4000 cycles | 4500 cycles | 5000 cycles | 5500 cycles | 6000 cycles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $L_1$ | 31.8 | 3.18 | 2.12 | 1.59 | 1.27 | 1.06 | .909 | .796 | .707 | .637 | .579 | .531 |
| | $L_2$ | .0199 | .00199 | .00133 | 995m | 796m | 663m | 569m | 497m | 442m | 398m | 362m | 332m |
| .05 | $C_1$ | .0796 | .00796 | .00531 | .00398 | .00318 | .00265 | .00227 | .00199 | .00177 | .00159 | .00145 | .00133 |
| | $C_2$ | 127 | 12.7 | 8.49 | 6.37 | 5.09 | 4.24 | 3.64 | 3.18 | 2.83 | 2.55 | 2.32 | 2.12 |
| | $L_1$ | 15.9 | 1.59 | 1.06 | .796 | .637 | .531 | .455 | .398 | .354 | .318 | .289 | .265 |
| | $L_2$ | .0398 | .00398 | .00265 | .00199 | .00159 | .00133 | .00114 | 995m | 884m | 796m | 723m | 663m |
| .1 | $C_1$ | .159 | .0159 | .0106 | .00796 | .00637 | .00531 | .00455 | .00398 | .00354 | .00318 | .00289 | .00265 |
| | $C_2$ | 63.7 | 6.37 | 4.24 | 3.18 | 2.55 | 2.12 | 1.82 | 1.59 | 1.41 | 1.27 | 1.16 | 1.06 |
| | $L_1$ | 10.6 | 1.06 | .707 | .531 | .424 | .354 | .303 | .265 | .236 | .212 | .193 | .177 |
| | $L_2$ | .0597 | .00597 | .00398 | .00298 | .00239 | .00199 | .00171 | .00149 | .00133 | .00119 | .00109 | 995m |
| .15 | $C_1$ | .239 | .0239 | .0159 | .0119 | .00955 | .00796 | .00682 | .00597 | .00531 | .00477 | .00434 | .00398 |
| | $C_2$ | 42.4 | 4.24 | 2.83 | 2.12 | 1.70 | 1.41 | 1.21 | 1.06 | .943 | .849 | .772 | .707 |
| | $L_1$ | 7.96 | .796 | .531 | .398 | .318 | .265 | .227 | .199 | .177 | .159 | .145 | .133 |
| | $L_2$ | .0796 | .00796 | .00531 | .00398 | .00318 | .00265 | .00227 | .00199 | .00177 | .00159 | .00145 | .00133 |
| .2 | $C_1$ | .318 | .0318 | .0212 | .0159 | .0127 | .0106 | .00909 | .00796 | .00707 | .00637 | .00579 | .00531 |
| | $C_2$ | 31.8 | 3.18 | 2.12 | 1.59 | 1.27 | 1.06 | .909 | .796 | .707 | .637 | .579 | .531 |
| | $L_1$ | 6.37 | .637 | .424 | .318 | .255 | .212 | .182 | .159 | .141 | .127 | .116 | .106 |
| | $L_2$ | .0995 | .00995 | .00663 | .00497 | .00398 | .00332 | .00284 | .00249 | .00221 | .00199 | .00181 | .00166 |
| .25 | $C_1$ | .398 | .0398 | .0265 | .0199 | .0159 | .0133 | .0114 | .00995 | .00884 | .00796 | .00723 | .00663 |
| | $C_2$ | 25.5 | 2.55 | 1.70 | 1.27 | 1.01 | .849 | .728 | .637 | .566 | .509 | .463 | .424 |
| | $L_1$ | 5.31 | .531 | .354 | .265 | .212 | .177 | .152 | .133 | .118 | .106 | .0965 | .0884 |
| | $L_2$ | .119 | .0119 | .00796 | .00597 | .00477 | .00398 | .00341 | .00298 | .00265 | .00239 | .00217 | .00199 |
| .3 | $C_1$ | .477 | .0477 | .0318 | .0239 | .0191 | .0159 | .0136 | .0119 | .0106 | .00955 | .00868 | .00796 |
| | $C_2$ | 21.2 | 2.12 | 1.41 | 1.06 | .849 | .707 | .606 | .531 | .472 | .424 | .386 | .354 |
| | $L_1$ | 3.98 | .398 | .265 | .199 | .159 | .133 | .111 | .0995 | .0884 | .0796 | .0723 | .0663 |
| | $L_2$ | .159 | .0159 | .0106 | .00796 | .00637 | .00531 | .00455 | .00398 | .00354 | .00318 | .00289 | .00265 |
| .4 | $C_1$ | .637 | .0637 | .0424 | .0318 | .0255 | .0212 | .0182 | .0159 | .0141 | .0127 | .0116 | .0106 |
| | $C_2$ | 15.9 | 1.59 | 1.06 | .796 | .637 | .531 | .455 | .398 | .354 | .318 | .289 | .265 |
| | $L_1$ | 3.18 | .318 | .212 | .159 | .127 | .106 | .0909 | .0796 | .0707 | .0637 | .0479 | .0531 |
| | $L_2$ | .199 | .0199 | .0133 | .00995 | .00796 | .00663 | .00568 | .00497 | .00442 | .00398 | .00362 | .00332 |
| .5 | $C_1$ | .796 | .0796 | .0531 | .0398 | .0318 | .0265 | .0227 | .0199 | .0177 | .0159 | .0145 | .0133 |
| | $C_2$ | 12.7 | 1.27 | .849 | .637 | .509 | .424 | .364 | .318 | .283 | .255 | .232 | .212 |
| | $L_1$ | 2.65 | .265 | .177 | .133 | .106 | .0884 | .0758 | .0663 | .0589 | .0531 | .0482 | .0442 |
| | $L_2$ | .239 | .0239 | .0159 | .0119 | .00955 | .00796 | .00682 | .00597 | .00531 | .00477 | .00434 | .00398 |
| .6 | $C_1$ | .955 | .0955 | .0637 | .0477 | .0382 | .0318 | .0273 | .0239 | .0212 | .0191 | .0174 | .0159 |
| | $C_2$ | 10.6 | 1.06 | .707 | .531 | .424 | .354 | .303 | .265 | .236 | .212 | .193 | .177 |
| | $L_1$ | 2.27 | .227 | .152 | .114 | .0909 | .0758 | .0650 | .0568 | .0505 | .0455 | .0413 | .0379 |
| | $L_2$ | .279 | .0279 | .0186 | .0139 | .0111 | .00928 | .00796 | .00696 | .00619 | .00557 | .00506 | .00464 |
| .7 | $C_1$ | 1.11 | .111 | .0742 | .0557 | .0446 | .0371 | .0318 | .0279 | .0248 | .0223 | .0203 | .0186 |
| | $C_2$ | 9.09 | .909 | .606 | .455 | .364 | .303 | .260 | .227 | .202 | .182 | .165 | .152 |
| | $L_1$ | 1.99 | .199 | .133 | .0995 | .0796 | .0663 | .0568 | .0497 | .0442 | .0398 | .0362 | .0332 |
| | $L_2$ | .318 | .0318 | .0212 | .0159 | .0127 | .0106 | .00909 | .00796 | .00707 | .00637 | .00579 | .00531 |
| .8 | $C_1$ | 1.27 | .127 | .0849 | .0637 | .0509 | .0424 | .0364 | .0318 | .0283 | .0255 | .0231 | .0212 |
| | $C_2$ | 7.96 | .796 | .531 | .398 | .318 | .265 | .227 | .199 | .177 | .159 | .145 | .133 |
| | $L_1$ | 1.77 | .177 | .118 | .0884 | .0707 | .0589 | .0505 | .0442 | .0393 | .0354 | .0322 | .0294 |
| | $L_2$ | .358 | .0358 | .0239 | .0179 | .0143 | .0119 | .0102 | .00895 | .00796 | .00716 | .00651 | .00597 |
| .9 | $C_1$ | 1.43 | .143 | .0955 | .0716 | .0573 | .0477 | .0409 | .0358 | .0318 | .0286 | .0260 | .0239 |
| | $C_2$ | 7.07 | .707 | .472 | .354 | .283 | .236 | .202 | .177 | .157 | .141 | .129 | .118 |

m = microhenries

continued next page

## TABLE II BAND-PASS FILTERS (R = 500 OHMS)

| Band Width | $f_m$ = | 6500 cycles | 7000 cycles | 7500 cycles | 8000 cycles | 8500 cycles | 9000 cycles | 9500 cycles | 10 kc. | 100 kc. | 1 mc. | 10 mc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $L_1$ | .490 | .455 | .424 | .398 | .374 | .354 | .335 | .318 | .0318 | .00318 | 318m |
| | $L_2$ | 306m | 284m | 265m | 249m | 234m | 221m | 209m | 199m | 19.9m | 1.99m | .199m |
| .05 | $C_1$ | .00122 | .00114 | .00106 | 995mmf. | 936mmf. | 884mmf. | 838mmf. | 796mmf. | 79.6mmf. | 7.96mmf. | .796mmf. |
| | $C_2$ | 1.96 | 1.82 | 1.70 | 1.59 | 1.50 | 1.41 | 1.34 | 1.27 | .127 | .0127 | .00127 |
| | $L_1$ | .245 | .227 | .212 | .199 | .187 | .177 | .168 | .159 | .0159 | .00159 | 159m |
| | $L_2$ | 612m | 568m | 531m | 497m | 468m | 442m | 419m | 398m | 39.8m | 3.98m | .398m |
| .1 | $C_1$ | .00245 | .00227 | .00212 | .00199 | .00187 | .00177 | .00168 | .00159 | 159mmf. | 15.9mmf. | 1.59mmf. |
| | $C_2$ | .979 | .909 | .849 | .796 | .749 | .707 | .670 | .637 | .0637 | .00637 | 637mmf. |
| | $L_1$ | .163 | .152 | .141 | .133 | .125 | .118 | .112 | .106 | .0106 | .00106 | 106m |
| | $L_2$ | 918m | 852m | 796m | 746m | 702m | 663m | 628m | 597m | 59.7m | 5.97m | .597m |
| .15 | $C_1$ | .00367 | .00341 | .00318 | .00298 | .00281 | .00265 | .00251 | .00239 | 239mmf. | 23.9mmf. | 2.39mmf. |
| | $C_2$ | .653 | .606 | .566 | .531 | .499 | .472 | .447 | .424 | .0424 | .00424 | 424mmf. |
| | $L_1$ | .122 | .114 | .106 | .0995 | .0936 | .0084 | .0838 | .0796 | .00796 | 796m | 79.6m |
| | $L_2$ | .00122 | .00114 | .00106 | .995m | 936m | 884m | 838m | 796m | 79.6m | 7.96m | .796m |
| .2 | $C_1$ | .00490 | .00455 | .00424 | .00398 | .00374 | .00354 | .00335 | .00318 | 318mmf. | 31.8mmf. | 3.18mmf. |
| | $C_2$ | .490 | .455 | .424 | .398 | .374 | .354 | .335 | .318 | .0318 | .00318 | 318mmf. |
| | $L_1$ | .0979 | .0909 | .0849 | .0796 | .0749 | .0707 | .0670 | .0637 | .00637 | 637m | 63.7m |
| | $L_2$ | .00153 | .00142 | .00133 | .00124 | .00117 | .00111 | .00105 | 995m | 99.5m | 9.95m | .995m |
| .25 | $C_1$ | .00612 | .00568 | .00531 | .00497 | .00468 | .00442 | .00419 | .00398 | 398mmf. | 39.8mmf. | 3.98mmf. |
| | $C_2$ | .392 | .364 | .340 | .318 | .300 | .283 | .268 | .255 | .0255 | .00255 | 255mmf. |
| | $L_1$ | .0816 | .0758 | .0707 | .0663 | .0624 | .0589 | .0558 | .0531 | .00531 | 531m | 53.1m |
| | $L_2$ | .00184 | .00171 | .00159 | .00149 | .00140 | .00133 | .00126 | .00119 | 119m | 11.9m | 1.19m |
| .3 | $C_1$ | .00735 | .00682 | .00637 | .00597 | .00562 | .00531 | .00503 | .00477 | 477mmf. | 47.7mmf. | 4.77mmf. |
| | $C_2$ | .326 | .303 | .283 | .265 | .250 | .236 | .223 | .212 | .0212 | .00212 | 212mmf. |
| | $L_1$ | .0612 | .0568 | .0531 | .0497 | .0468 | .0442 | .0419 | .0398 | .00398 | 398m | 39.8m |
| | $L_2$ | .00245 | .00227 | .00212 | .00199 | .00187 | .00177 | .00168 | .00159 | 159m | 15.9m | 1.59m |
| .4 | $C_1$ | .00979 | .00909 | .00849 | .00796 | .00749 | .00707 | .00670 | .00637 | 637mmf. | 63.7mmf. | 6.37mmf. |
| | $C_2$ | .245 | .227 | .212 | .199 | .187 | .177 | .168 | .159 | .0159 | .00159 | 159mmf. |
| | $L_1$ | .0490 | .0455 | .0424 | .0398 | .0374 | .0354 | .0335 | .0318 | .00318 | 318m | 31.8m |
| | $L_2$ | .00306 | .00284 | .00265 | .00249 | .00234 | .00221 | .00209 | .00199 | 199m | 19.9m | 1.99m |
| .5 | $C_1$ | .0122 | .0114 | .0106 | .00995 | .00936 | .00884 | .00838 | .00796 | 796mmf. | 79.6mmf. | 7.96mmf. |
| | $C_2$ | .196 | .182 | .170 | .159 | .150 | .141 | .134 | .127 | .0127 | .00127 | 127mmf. |
| | $L_1$ | .0408 | .0379 | .0354 | .0332 | .0312 | .0295 | .0279 | .0265 | .00265 | 265m | 26.5m |
| | $L_2$ | .00367 | .00341 | .00318 | .00298 | .00281 | .00265 | .00251 | .00239 | 239m | 23.9m | 2.39m |
| .6 | $C_1$ | .0147 | .0136 | .0127 | .0119 | .0113 | .0106 | .0101 | .00955 | 955mmf. | 95.5mmf. | 9.55mmf. |
| | $C_2$ | .163 | .152 | .141 | .133 | .125 | .118 | .112 | .106 | .0106 | .00106 | 106mmf. |
| | $L_1$ | .0350 | .0325 | .0303 | .0284 | .0267 | .0253 | .0239 | .0227 | .00227 | 227m | 22.7m |
| | $L_2$ | .00429 | .00398 | .00371 | .00348 | .00328 | .00309 | .00293 | .00279 | 279m | 27.9m | 2.79m |
| .7 | $C_1$ | .0171 | .0159 | .0149 | .0139 | .0131 | .0124 | .0117 | .0111 | .00111 | 111mmf. | 11.1mmf. |
| | $C_2$ | .140 | .130 | .121 | .114 | .107 | .101 | .0957 | .0909 | .00909 | 909mmf. | 9.09mmf. |
| | $L_1$ | .0306 | .0284 | .0265 | .0249 | .0234 | .0221 | .0209 | .0199 | .00199 | 199m | 19.9m |
| | $L_2$ | .00490 | .00455 | .00424 | .00398 | .00374 | .00254 | .00335 | .00318 | 318m | 31.8m | 3.18m |
| .8 | $C_1$ | .0196 | .0182 | .0170 | .0159 | .0150 | .0141 | .0134 | .0127 | .00127 | 127mmf. | 12.7mmf. |
| | $C_2$ | .122 | .113 | .106 | .0995 | .0936 | .0884 | .0838 | .0796 | .00796 | 796mmf. | 79.6mmf. |
| | $L_1$ | .0272 | .0253 | .0236 | .0221 | .0208 | .0196 | .0186 | .0177 | .00177 | 177m | 17.7m |
| | $L_2$ | .00551 | .00512 | .00477 | .00448 | .00421 | .00398 | .00377 | .00358 | 358m | 35.8m | 3.58m |
| .9 | $C_1$ | .0220 | .0205 | .0191 | .0179 | .0169 | .1059 | .0151 | .0143 | .00143 | 143mmf. | 14.3mmf. |
| | $C_2$ | .109 | .101 | .0943 | .0884 | .0832 | .0786 | .0745 | .0707 | .00707 | 707mmf. | 70.7mmf. |

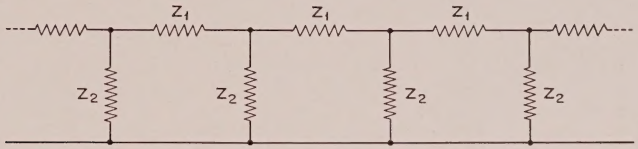



Figure 1

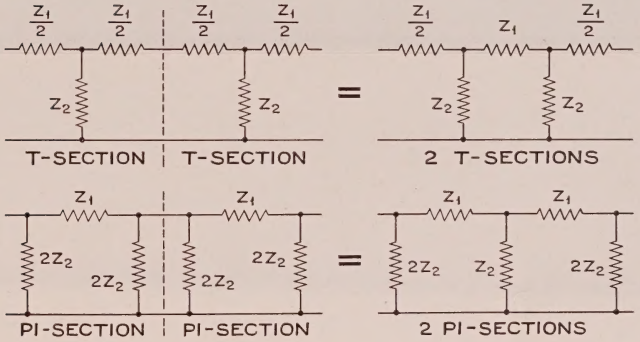



Figure 2

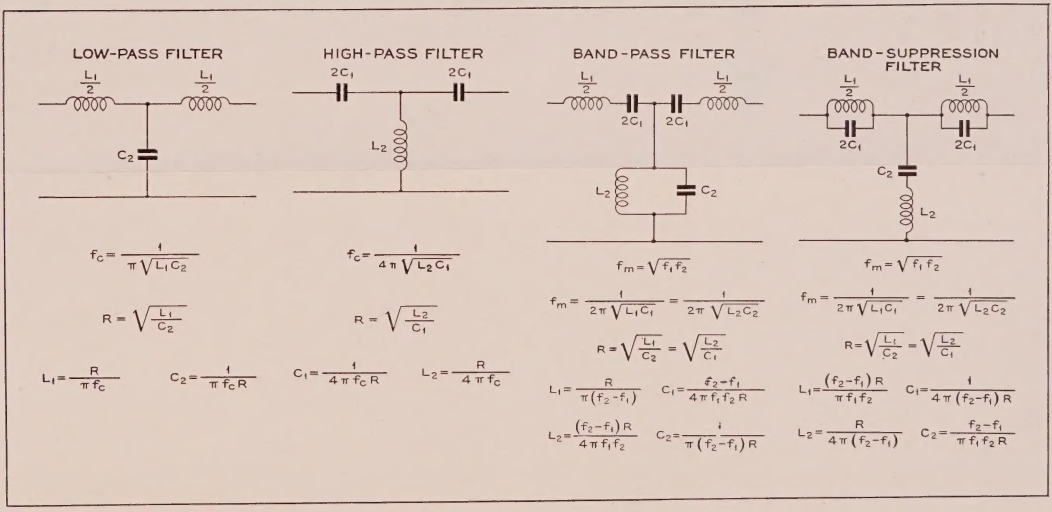
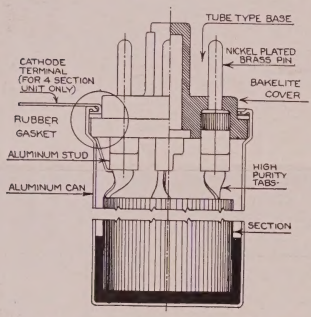



Figure 3

*Something new and startling . . .*

# PLUG - IN ELECTROLYTICS




As shown above, octal base of Aerovox plug-in condenser is of special design and construction, made in Aerovox's own molding department.

Nickel-plated brass prongs engage with standard octal socket contacts of similar metal. Prongs connect with aluminum-section tabs through aluminum studs, as shown, with junctions imbedded in protective bakelite seal to eliminate corrosive effects. Aluminum studs spun over prong ends. Section tab placed in cylindrical recess of aluminum stud, and portion of stud is partly sheared and collapsed on imbedded tab for permanently low-resistance, aluminum-to-aluminum bond.

Hermetic sealing achieved by can edge spun over soft-rubber gasket and bakelite plug. Vented cover for finish protection.

If standard octal socket is correctly wired, condenser simply cannot be correctly connected because of octal base keying.

Units firmly gripped in octal sockets just as in case of octal-base radio tubes and vibrators.

● Developed primarily for the U. S. Signal Corps and for use in aircraft and police radio, the new AEROVOX Series AP Plug-in Electrolytic Condensers are now available for other applications where, above all else, continuity of service is a prime requisite.

The far-reaching advantages of the plug-in electrolytic are at once obvious. Readily removed, tested, replaced, these octal-base condensers handle with the same ease as conventional radio tube or vibrator. Assemblies can be equipped with fresh plug-ins immediately prior to shipment or to actual use, which feature is vitally important in overseas radio trade. Users of radio or electronic equipment subject to continuous service, can carry "spares" on hand for instant replacement. Auto-radio and home-radio service is vastly simplified.

The many technical problems involved in producing a hermetically-sealed, leak-proof, corrosion-proof, octal-base plug-in condenser have been thoroughly solved. These units are available in the paper type as well as in electrolytic as herein listed.

**AEROVOX TYPE AEP**
**Plug-In Electrolytics**

**Max. 525v. SURGE 450v. D.C. Work.**

**Type AEP-450—Single Section**

| Cap. Mfds. | Size-Ins. Dia.-High | List Price |
|---|---|---|
| 10 | 1-5/32 x 2-1/2 | $1.25 |
| 20 | 1-5/32 x 2-1/2 | 1.75 |
| 40 | 1-5/32 x 2-1/2 | 3.05 |
| 80 | 1-5/32 x 4-1/4 | 4.25 |

**Type AEP-450—Double Section**

| | | |
|---|---|---|
| 10–10 | 1-5/32 x 2-1/2 | 1.95 |
| 20–20 | 1-5/32 x 3 | 2.75 |

**Type AEP-450—Triple Section**

| | | |
|---|---|---|
| 10-10-10 | 1-5/32 x 2-1/2 | 2.65 |

**Type AEP 45025**

| | | |
|---|---|---|
| 10-10 x 450 +20 x 25 | 1-5/32 x 2-1/2 | 2.65 |

## *Ask Your Jobber . . .*

Ask to see this latest achievement in condensers. Use plug-in condensers in that next assembly intended for continuous, dependable service. Or write us direct.

**AEROVOX CORPORATION**
*New Bedford, Mass.*
**Sales Offices in All Principal Cities**